Government of Western Australia
Department of Water and Environmental Regulation

Nilgen Water Reserve

drinking water source protection review

Ocean Farms Estate, Nilgen town water supply

Water resource protection series
Report WRP198
August 2021

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Department of Water and Environmental Regulation
Prime House, 8 Davidson Terrace
Joondalup Western Australia 6027
Locked Bag 10 Joondalup DC WA 6919

Phone: 08 6364 7000
Fax: 08 6364 7001
National Relay Service 13 36 77

dwer.wa.gov.au

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The following people contributed to this publication: Sue Tillman, Stephen Watson, Gerard Paul, Hisayo Thornton (Department of Water and Environmental Regulation), Rose Carruthers and Michael Sawyer (Water Corporation).

For more information about this report, contact the Water Source Protection Planning team on +61 8 6364 7600 or drinkingwater@dwer.wa.gov.au.

Cover photograph: Aerial photograph of Nilgen Water Reserve

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Summary

This drinking water source protection review considers changes that have occurred in the Nilgen Water Reserve since the *Nilgen Water Reserve drinking water source protection plan* (2010) was released. The plan still contains relevant information, so it is important that the plan and this review are read in conjunction. Both are available on the Department of Water and Environmental Regulation's (the department) website or by contacting us.

This review reflects key changes to the protection plan, reports on the implementation of the recommendations in that plan and provides new and updated recommendations.

Together with the plan, the review:

- identifies land uses and activities within the Nilgen Water Reserve
- identifies priority areas and wellhead protection zones that reflect existing land uses and zoning
- helps guide future land use planning and activities
- creates awareness and educates stakeholders about the importance of the Nilgen Water Reserve
- helps ensure the ongoing availability of a safe and good quality drinking water supply for Ocean Farms Estate, Nilgen.

Nilgen is a small settlement of approximately 230 people (ABS 2016) about 130 km north of Perth, Western Australia (Figure A1). Ocean Farms is a rural living estate in Nilgen, in the Shire of Gingin.

Drinking water for Ocean Farms Estate is sourced from the Nilgen Water Reserve, located within the estate (Figure A1). The Nilgen Water Reserve was gazetted as a public drinking water source area (PDWSA) under the C*ountry Areas Water Supply Act, 1947* on 19 February 2019.

The Water Corporation currently abstracts groundwater from one production bore (Bore 1) in the Nilgen Water Reserve to supply drinking water to the Ocean Farms Estate. Another production bore (1/19) has been drilled nearby for future use, planned to come into operation in the 2020/21 financial year (Photograph C1 and C2). The bores are vulnerable to contamination from surrounding land uses because water is drawn from the unconfined superficial aquifer at Nilgen.

To help protect the drinking water source, land in the Nilgen Water Reserve was assigned as priority 1 (P1) and priority 2 (P2) areas, with a 300 m wellhead protection zone (WHPZ) around Bore 1, providing an extra level of protection in the immediate vicinity of the drinking water abstraction point. No changes to the priority areas are proposed.

This review proposes the following changes to the Nilgen Water Reserve (see Figure A4), which are not expected to affect private landowners:

- Realign the WHPZ to more accurately reflect Bore 1's location and protect new Bore 1/19. The department will update this in its spatial data after publishing this review.
- Update a small area of the Nilgen Water Reserve boundary to match the realigned WHPZ. After this review is published, the department will initiate this via a formal amendment of the water reserve under the *Country Areas Water Supply Act,* 1947, which will include consultation with affected stakeholders.

The department prepared this document in consultation with the Shire of Gingin, Water Corporation, Department of Health, South West Aboriginal Land and Sea Council and private land owners. No contentious issues were raised. Key stakeholders will be contacted again prior to the boundary amendment process.

This review implements the *Australian drinking water guidelines* (ADWG), which are published by the National Health and Medical Research Council (NHMRC & NRMMC 2011, August 2018 update). The Minister for Health, Hon Roger Cook MLA (Minister for Health) endorsed the August 2018 update of the ADWG as the basis for setting policy for drinking water quality, safety and risk management in WA. It is also consistent with State planning policy 2.7: *Public drinking water source policy* (Western Australian Planning Commission 2003) and Strategic policy: *Protecting public drinking water source areas in Western Australia* (Department of Water 2016a), which outline how PDWSAs are managed in WA.

Information about the Nilgen Water Reserve is in Table 1.

Table 1 Key information about the Nilgen Water Reserve

Nilgen Water Reserve	
Local government	Shire of Gingin
Location supplied	Ocean Farms Estate, Nilgen
Number of services supplied	161 services
Water service provider	Water Corporation
Aquifer type	Unconfined, making it vulnerable to contamination from surface-based land uses and activities
Water reserve size	233 ha
Licence to take water	GWL63819 – allocation of 529 500kL per year, issued under the *Rights in Water and Irrigation Act 1914*
Number of bores	2 production bores (1 currently used)

<table>
<tr><th colspan="5">Nilgen Water Reserve</th></tr>
<tr><td rowspan="3">Bore details</td><td>Bore name</td><td>Date drilled</td><td>Depth (m)</td><td>Coordinates (MGA, zone 50)</td></tr>
<tr><td>Bore 1 (current)</td><td>1980 (month not listed)</td><td>120</td><td>E 347 343; N 6 572 678</td></tr>
<tr><td>1/19
(future)</td><td>13 April 2019</td><td>123</td><td>E 347 350; N 6 572 675</td></tr>
<tr><td>Native Title</td><td colspan="4">South West Aboriginal Land and Sea Council, Yued Working Party</td></tr>
<tr><td>Date/s of drinking water source protection reports</td><td colspan="4">2010 – Nilgen Water Reserve drinking water source protection plan (Department of Water)
2021 – Nilgen Water Reserve drinking water source protection review (this document)</td></tr>
<tr><td>Consultation</td><td colspan="4">2010 – consultation with key stakeholders as part of the water source protection plan
2020 – consultation with key stakeholders as part of this review</td></tr>
<tr><td>Gazettal status/history</td><td colspan="4">Gazetted on 19 February 2019 under the Country Areas Water Supply Act 1947.
This review proposes a small amendment to the Nilgen Water Reserve boundary under the Country Areas Water Supply Act 1947. The department will organise this gazettal after finalising this report.</td></tr>
<tr><td>Reference documents</td><td colspan="4">Australian drinking water guidelines (NHMRC & NRMMC 2011)
State planning policy 2.7: Public drinking water source policy (Western Australian Planning Commission 2003)
Shire of Gingin Local Planning Scheme No. 9 (Department of Planning, Lands and Heritage, 2012 last updated 2019)
Gingin Groundwater Area water allocation plan (Department of Water 2015)</td></tr>
</table>

1 Review of Nilgen Water Reserve drinking water source protection plan

1.1 Water supply scheme

The Water Corporation abstracts groundwater from the Nilgen Water Reserve to supply drinking water to the Ocean Farms Estate. The Nilgen bore field consists of two bores located on the western side of the water reserve (see Appendix A Figure A2, A3 and A4). Bore 1 is currently in use while Bore 1/19 has been drilled but not equipped (see Appendix C, Photograph C2). The two bores are in the same compound (Photograph C1 and C2) and will operate on an alternating duty/standby basis when Bore 1/19 comes into operation (planned 2020/21). The bores are in the unconfined aquifer and therefore vulnerable to contamination from surrounding land uses.

Groundwater abstracted from this source for drinking water undergoes chlorination within the bore compound. Disinfected water is then pumped to the Nilgen tank site (5 tanks, see Appendix C, Photograph C4) and gravity fed to the town. The reticulation mains within the scheme were replaced last year to bring them in line with Water Corporation's standards. An upgrade to the drinking water storage tanks is planned for the 2020/21 financial year. The bores and associated treatment and storage infrastructure are located in securely fenced and signed compounds to restrict access (Photograph C1 and C4). Water Corporation currently supply 161 services from this bore field.

Public drinking water source area (PDWSA) management is the first step in protecting water quality and ensuring a safe drinking water supply. Although treatment and disinfection are essential barriers against contamination, catchment protection is the most important, as advocated by the *Australian drinking water guidelines* (ADWG; NHMRC & NRMMC 2011, August 2018 update). The ADWG is based on preventing risks and managing multiple barriers for providing safe drinking water to consumers. This combination of catchment protection and water treatment delivers a more reliable, safer and lower cost drinking water to consumers than either approach could achieve individually.

For more information about how the department protects PDWSAs, read Appendix E.

1.2 Water licensing and planning

The Water Corporation holds a water service provider licence from the Economic Regulation Authority which allows it to provide drinking water services.

The department has issued Water Corporation with a groundwater licence under the *Rights in Water and Irrigation Act 1914*. GWL63819(6) allows the abstraction of 529,500 kL of water from the Gingin Groundwater Area, Lancelin subarea, Perth Superficial aquifer to supply drinking water to Ocean Farms Estate. This licence expires in 2024.

Population growth is still occurring within the estate as more vacant lots are developed. However as the current licensed allocation is underutilised, it is anticipated to meet demand for the foreseeable future.

1.3 Boundary

The Nilgen Water Reserve was constituted in February 2019 under the *Country Areas Water Supply Act 1947*. The boundary, developed as part of the 2010 plan, reflects the portion of the recharge area for the Nilgen bore field which lies within the Ocean Farms Estate. Recharge to the superficial aquifer in the Nilgen vicinity is generally via rainfall from May to September, with groundwater in the reserve generally flowing in an east to west direction.

The Nilgen Water Reserve boundary requires a slight amendment to reflect the realignment of the WHPZ (see section 1.4 and Figure A4). The department will amend the Nilgen Water Reserve under the *Country Areas Water Supply Act 1947* (see recommendation no. 1, section 3.2).

1.4 Priority areas and protection zones

The 2010 plan assigned a P1 area over land owned by the government or Water Corporation in the Nilgen Water Reserve. P2 areas were assigned over privately owned rural-residential land. Since then, land tenure, land uses and activities have remained relatively consistent (see Appendix A, Figure A2 and A3). As a result, this review proposes no changes to the priority areas.

The 2010 plan also assigned a 300 m WHPZ around Bore 1, for additional protection from contamination in the immediate vicinity of the drinking water abstraction. Since then, better spatial data has placed Bore 1's location further to the north than previously recorded. Additionally, future production Bore 1/19 has been drilled relatively close to Bore 1 (Photograph C2). The central point of the WHPZ will therefore be realigned approximately 19 m to the north, midway between the bores. This single WHPZ will adequately protect both bores. The WHPZ will be updated on the department's spatial database after this review is published.

Figure A4 in Appendix A shows the existing and proposed boundary, priority areas and protection zone for the Nilgen Water Reserve.

The boundary, priority areas and protection zones have been determined in accordance with the department's Strategic policy: *Protecting public drinking water source areas in Western Australia* (Department of Water 2016a).

1.5 Land use planning

There are no foreseeable implications to land holders within the Nilgen Water Reserve from the small changes to the boundary and WHPZ (see section 1.4):

- Existing, legally approved land uses can continue.

- Landholders should use best management practices to avoid or reduce contamination risks to the drinking water source.
- New land uses and activities or expansion beyond currently approved limits would require approval from the Shire of Gingin, who would seek advice from the department.

Local planning

The majority of land within the Nilgen Water reserve is zoned 'rural living', with smaller parcels zoned 'public use' in the Shire of Gingin's *Local Planning Scheme no. 9* (Department of Planning, Lands and Heritage 2012, last updated 2019). The local scheme does not have a special control area for this PDWSA and the department recommends that the shire consider this for its next scheme update to help recognise the PDWSA in the land use planning process (see section 3.2, recommendation 2).

1.6 Aboriginal sites of significance

Aboriginal sites of significance are important places with special cultural connections to Aboriginal people. They are important because they link Aboriginal cultural tradition to place, land and people over time. These sites are integral to the lives of Aboriginal people, and are found in urban, rural and remote areas. They are most common near rivers, lakes, swamps, hills and the coast. The *Aboriginal Heritage Act 1972* protects all Aboriginal places and objects that are culturally important to Aboriginal people. It is against the law to disturb a site or to remove artefacts, however this at the discretion of the Minister of Aboriginal Affairs, Hon Ben Wyatt MLA.

There are no recorded Aboriginal sites of significance within the Nilgen Water Reserve.

1.7 Native title claims

Native title is the recognition in Australian law that some Aboriginal people continue to hold native title rights and interests in lands and waters.

The Nilgen Water Reserve lies within the Yued claim area.

The State Government of Western Australia and the Noongar native title claimants have negotiated a South West Native Title Settlement. This settlement recognises the Noongar people as the traditional owners of land in the South West Settlement Area (see Appendix A, Figure A5) which includes the Nilgen Water Reserve. This was formally recognised on 6 June 2016 by the WA Parliament in the *Noongar (Koorah, Nitja, Boordahwan) (Past, Present, Future) Recognition Act 2016*.

The settlement includes six identical Indigenous Land Use Agreements (ILUAs), which were registered on 17 October 2018. On 19 December 2019, the Full Federal Court upheld the Native Title Registrar's decision to register the six South West Settlement ILUAs. Once all legal proceedings are resolved and the six ILUAs are

conclusively registered, the Settlement can commence (estimated to be after mid-2020). Current information on the settlement and ILUAs is available on the Department of Premier and Cabinet's website (www.dpc.wa.gov.au).

The agreements already enable some types of land-based customary activities to be undertaken by Noongar people in PDWSAs within the South West Settlement Area. On 8 June 2016, the department amended two sets of by-laws (*Metropolitan Water Supply, Sewerage and Drainage By-laws 1981* and the *Country Areas Water Supply By-laws 1957*) to support the agreement. These amended by-laws currently apply within the Nilgen Water Reserve.

The department is committed to working with Aboriginal people in its planning and management activities and recognises that native title is an important framework for water management.

1.8 Enforcing by-laws, surveying the area and maintenance

The department recommends that the Water Corporation continue by-law enforcement under the existing delegation arrangement (see section 3.2, recommendations no. 5 and 6). This also includes:

- erecting and maintaining signs in accordance with *S111 Source protection signage* (Water Corporation 2013). Appendix C, Photograph C5, shows an example of signage posted in the Nilgen Water reserve.
- maintaining security and fencing surrounding the bore field and storage tank complex
- ongoing regular surveillance and inspections.

1.9 Related water source management work

Gingin groundwater allocation plan (2015)

The department developed this allocation plan to manage groundwater resources in the Gingin groundwater area, which includes the Nilgen Water Reserve, in the context of our drying climate and high water demand. It discusses allocation limits and licensing rules which help support development in the area whilst reducing risk to the surrounding groundwater-dependent environment. Information about groundwater allocated for public water supply is provided in the plan. A copy can be found on our website or by contacting us.

1.10 Update on water quality risks

As part of this review, the department has conducted an updated assessment of water quality contamination risks to the Nilgen Water Reserve drinking water source, in accordance with the ADWG.

Land uses within the Nilgen Water Reserve have remained consistent since the 2010 plan with the majority of the estate zoned for rural living (see Appendix A, Figure A2).

Table 2 provides a summary of the land use and activities in the Nilgen Water Reserve. These land uses are present within the WHPZ, posing an ongoing high risk to the vulnerable shallow drinking water source. In order to protect Ocean Farms Estate's drinking water source, it is important that best management practices are used by all land owners and managers within the Nilgen Water Reserve to address contamination risks. Examples of relevant best management practices are given below in Table 2 and in the 'Further reading' section.

Refer to Appendix D for information about typical contamination risks in PDWSAs. Refer to Appendix E to gain a greater understanding about the risk assessment process the department uses in PDWSAs.

Rural-living lots

Ocean Farms Estate is made up of rural living lots of 2-4 hectares in size (see Appendix C, Photograph C6). Further development in the estate has resulted in increased contamination risks to the drinking water source from cumulative impacts. The main contamination risks include pathogens and nutrients from septic tanks and domestic animals, chemicals from pesticides and hydrocarbons and chemicals from vehicles and machinery.

Roads and tracks

Roads and tracks are present in the Nilgen Water Reserve (Figure A2-A4). Ocean Farm Drive, a sealed road runs directly past the Nilgen bore field (Photograph C3) as does an unsealed track used to access the Water Corporation sites (Photograph C6). The main contamination risks from roads and tracks include hydrocarbons and chemicals from spills and leaks. This is particularly important in the WHPZ and on unsealed roads where potential contamination risk to the drinking water source is higher.

Drinking water treatment

The drinking water treatment facilities are located within the water reserve (see Figure A1 and A2). The main risk is chemicals from water treatment processes. Water Corporation use best management practices apply to ensure the drinking water source is kept safe.

Fire management

The main risks from wildfire management include chemicals from firefighting foams and herbicides from firebreak maintenance. There are parcels of uncleared vegetation which present a fire risk (Figure A2). Fire may also interrupt water supply if it damages the bore and treatment plant's electrical supply (Photograph C3). State Hazard Plan – HAZMAT protocols are in place to manage emergencies such as

wildfire in the water reserve. Chemicals used should be in accordance with the Department of Health's PSC 88: *Use of herbicides in water catchment areas.*

Recreation

There is a 4.6 ha parcel of unallocated crown land in the centre of the Nilgen Water Reserve stretching from the western to eastern boundary (Figure A3). It contains a track used by the Water Corporation to access the bore field and the tank site (Photograph C6). There is some potential for this land to be used for recreation.

The department's Operational policy 13: *Recreation within public drinking water source areas on Crown land* applies to this land parcel. The policy's intent is to protect drinking water quality and public health by managing recreation in PDWSAs. The policy supports existing, approved recreation events and facilities prior to September 2012. New recreation should be located outside of the PDWSA for the protection of water quality and public health. Please read the policy for more information.

Unauthorised recreation has not been reported as a problem in the Nilgen Water Reserve.

Other groundwater bores

Bores drilled near a public drinking water supply bore (such as for irrigation or private purposes) can cause contamination of the drinking water source. For example, a poorly constructed bore may introduce contaminants from surface leakage down the outside of the bore casing into an otherwise uncontaminated aquifer.

It is therefore important to ensure that any bores are appropriately located and constructed to prevent contamination of the public drinking water source. This will be assessed through the department's water licensing process where applicable under the *Rights in Water and Irrigation Act 1914.* All bores should be constructed in accordance with *Minimum construction requirements for water bores in Australia* (National Uniform Drillers Licensing Committee 2012). It is important that GIS coordinates for all bores are recorded correctly, to ensure proper assessment of the risk to drinking water bores.

No other licensed groundwater bores are in the Nilgen Water Reserve or within 500 m of the production bores. However, groundwater may still be abstracted from private bores for stock watering and domestic use without a licence. The above recommendations should also be applied to private bores exempt from licensing.

Table 2 Summary of potential water quality risks, land use compatibility and best management practices

Land use/activity	Hazard	Management priority	Comments	Best management practice guidance[1]
Rural living zone; residential development and land uses	Pathogens and nutrients from septic tanks and domestic animals Chemicals from pesticides Nutrients from fertilisers	High High Medium	Rural living estates with a lot size of 2 ha or greater (as per Ocean Farms) are considered compatible with conditions in P2 areas. A single house, ancillary dwellings, stock grazing and stables are all considered acceptable in P2 areas. Risks are increasing due to cumulative impact as vacant lots in the estate are being developed. Land clearing may increase contamination risk to aquifer.	WQPN 48: *Water supplies for rural lots (non-potable use)* WQPN 70: *Wastewater treatment and disposal- domestic systems* WQPN 96: *Pest animal management in PDWSAs* Brochure: *Living and working in public drinking water source areas* Brochure: *Managing horses in semi-rural environments* PSC 88: *Use of herbicides in water catchment areas* (Department of Health) *Stocking rate guidelines for rural small holdings* (Department of Primary Industries and Regional Development)
Roads and tracks	Hydrocarbons and chemicals from spills and leaks	High	Roads are considered compatible with conditions in P1 and P2 areas. Unsealed roads and tracks need to be managed to control access.	WQPN 44: *Roads near sensitive water resources*

Land use/activity	Hazard	Management priority	Comments	Best management practice guidance[1]
Drinking water treatment	Chemicals from spills and leaks	High	Drinking water treatment plants are considered compatible with conditions in P1 and P2 areas.	WQPN 56: *Tanks for fuel and chemical storage near sensitive water resources*
Wild fire occurrence and management	Chemicals to fight wildfire Pesticides use for firebreak maintenance	High High	State Hazard Plan – HAZMAT protocols in place to manage emergencies such as wildfire in the water reserve. There are parcels of uncleared vegetation which present a fire risk. Clearing has occurred on lots for fire management and development.	State Hazard Plan – HAZMAT protocols PSC 88: *Use of herbicides in water catchment areas*
Recreation on Crown land	Pathogens from people and domestic animals Hydrocarbons from vehicles Pesticides for weed control/ firebreak management.	High Medium Medium	Unauthorised recreation has not been reported as a problem, however there is the potential for it to occur. New recreation events and facilities should occur outside of the PDWSA.	Operational policy No. 13: *Recreation within PDWSAs on Crown land*

[1] Water quality protection notes (WQPNs) are available at www.dwer.wa.gov.au or see *Further reading*.

1.11 Water quality information

The Water Corporation has provided updated water quality information for the Nilgen Water Reserve. This is shown in Appendix B.

No ADWG health guideline values were detected to be exceeded during this period. Aesthetic guidelines exceeded include ‘hardness as $CaCO_3$’ and ‘total filterable solids by summation’ that reflect the naturally occurring high level of minerals and salts in the groundwater.

It is important to appreciate that this raw-water data does not represent the quality of drinking water distributed to the public. Barriers such as storage and water treatment exist downstream of the raw water to ensure it meets the requirements of the ADWG and provision of safe drinking water to consumers.

2 Consultation

2.1 Stakeholder consultation process

The department consulted with the Shire of Gingin, Water Corporation, Department of Health, South West Land and Sea Council and private landholders to develop this review. Stakeholders were sent a letter discussing the 2010 plan, the aims of this review and the proposed changes for the Nilgen Water Reserve, with a map. Stakeholders were invited to provide comment to the department.

No contentious issues were raised during consultation.

3 Implementing Nilgen Water Reserve's drinking water source protection plan

3.1 Status of previous recommendations

Table 3 outlines recommendations from the 2010 plan and their current status.

Table 3 Implementation status for Nilgen Water Reserve

No.	Recommendation from the 2010 plan	Current status
1	Gazettal of water reserve.	Gazetted in 2019 under the *Country Areas Water Supply Act 1947.*
2	Develop implementation strategy.	This review provides specific recommendations in section 3.2 instead of a separate implementation strategy.
3	Incorporation into town planning scheme.	The water reserve has not been recognised in the Shire of Gingin's *Local planning scheme no. 9*. This review recommends to include it (section 3.2, recommendation no. 2).
4	Referral of development proposals: • The Department of Water[1] to provide the Shire of Gingin with guidelines for referral of development proposals • referral of development proposals by the Shire.	Guidelines have been provided through the WQPN series. Development proposals that are inconsistent with this review and WQPN 25: *Land use compatibility in public drinking water source areas* (Department of Water 2016b) should be referred to the department's Swan Avon Region for advice. This has been continued as a recommendation of this review (section 3.2, recommendation no. 3).

[1] The responsibilities of the former Department of Water have now been assumed by the Department of Water and Environmental Regulation.

No.	Recommendation from the 2010 plan	Current status
5	Emergency response: • develop response plan • inform WESTPLAN-HAZMAT personnel of special requirements for the Nilgen Water Reserve.	Emergency response protocols are now called State Hazard Plan – HAZMAT and have a local emergency management committee (LEMC). The Wheatbelt LEMC were advised of the function and location of the Nilgen Water Reserve in 2010. This has been continued as a recommendation of this review (section 3.2, recommendation no. 4).
6	Erection of signs: • development of guidelines for signage • determine number and location of signs required • erect signs.	Signs advising on the location of the Nilgen Water Reserve have been erected. Signs should be maintained and replaced as necessary. This has been continued as a new recommendation of this review (section 3.2, recommendation no. 5).
7	Surveillance program: • develop guidelines for the surveillance of water reserves • implement the surveillance program.	Water Corporation undertakes surveillance within the water reserve. This has been continued as a recommendation in this review (section 3.2, recommendation no. 6).
8	Water Corporation to investigate alternative bore locations away from contamination risks.	The current source will meet foreseeable demand, so a new source is not required at this time. Water Corporation has drilled a new bore in the same compound as the original bore for future use.
9	Review of the plan after 5 years	This document is the first review of the 2010 plan. This has been continued as a new recommendation of this review (section 3.2, recommendation no. 8).

3.2 Consolidated recommendations

Based on the findings of this review, the following recommendations will now be applied to the Nilgen Water Reserve. The stakeholders listed in brackets are responsible for, or have an interest in, implementing that recommendation.

1. After this report is published, the department will arrange constitution of the amended boundary of the Nilgen Water Reserve under the *Country Areas Water Supply Act 1947*. (Department of Water and Environmental Regulation)
2. Incorporate the findings of this review and the location of the Nilgen Water Reserve (including its priority areas and protection zone), in the Shire of Gingin's local planning scheme in accordance with State planning policy 2.7: *Public drinking water source policy*. The Nilgen Water Reserve should be recognised as a special control area in the scheme. (Shire of Gingin)
3. Refer development proposals within the Nilgen Water Reserve that are inconsistent with the department's WQPN 25: *Land use compatibility tables for public drinking water source areas* or recommendations in this review to the department's regional office for advice. (Department of Planning, Shire of Gingin, proponents of proposals)
4. Ensure incidents covered by State Hazard Plan – HAZMAT in the Nilgen Water Reserve are addressed by ensuring that:
   - the Wheatbelt emergency management committee is aware of the location and purpose of the Nilgen Water Reserve
   - the locality plan for the Nilgen Water Reserve is provided to the Department of Fire and Emergency Services headquarters for the HAZMAT emergency advisory team
   - the Water Corporation acts in an advisory role during incidents in the Nilgen Water Reserve
   - personnel dealing with State Hazard Plans incidents in the area have ready access to a locality map of the Nilgen Water Reserve and information to help them recognise the potential impacts of spills on drinking water quality.

   (Water Corporation)
5. Maintain signs along the boundary of the Nilgen Water Reserve including an emergency contact telephone number, in accordance with the Water Corporation's *S111 Source protection signage* (2013). (Water Corporation)
6. Water Corporation should continue the current regime of water quality monitoring, maintenance of fencing, inspections and by-law enforcement. (Water Corporation)
7. Water Corporation to advise the department when Bore 1/19 comes online as a production bore for the Nilgen scheme. (Water Corporation)

8. This report will be reviewed in seven years or in response to changes in water quality contamination risks. (Department of Water and Environmental Regulation)

Appendices

Appendix A – Figures

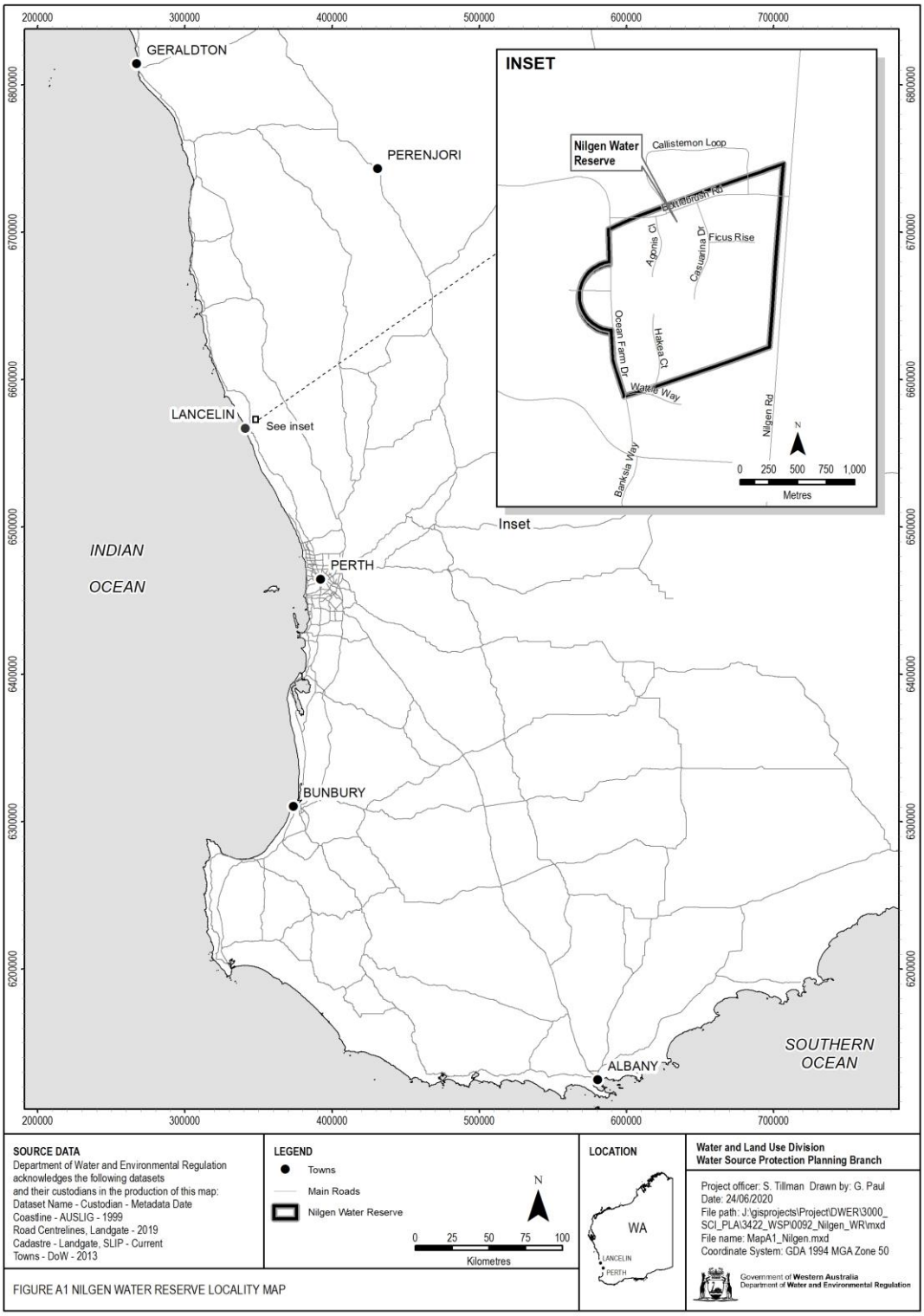

Figure A1 Nilgen Water Reserve locality map

Figure A2 Proposed Nilgen Water Reserve aerial photograph showing land uses

Figure A3 Proposed Nilgen Water Reserve land tenure

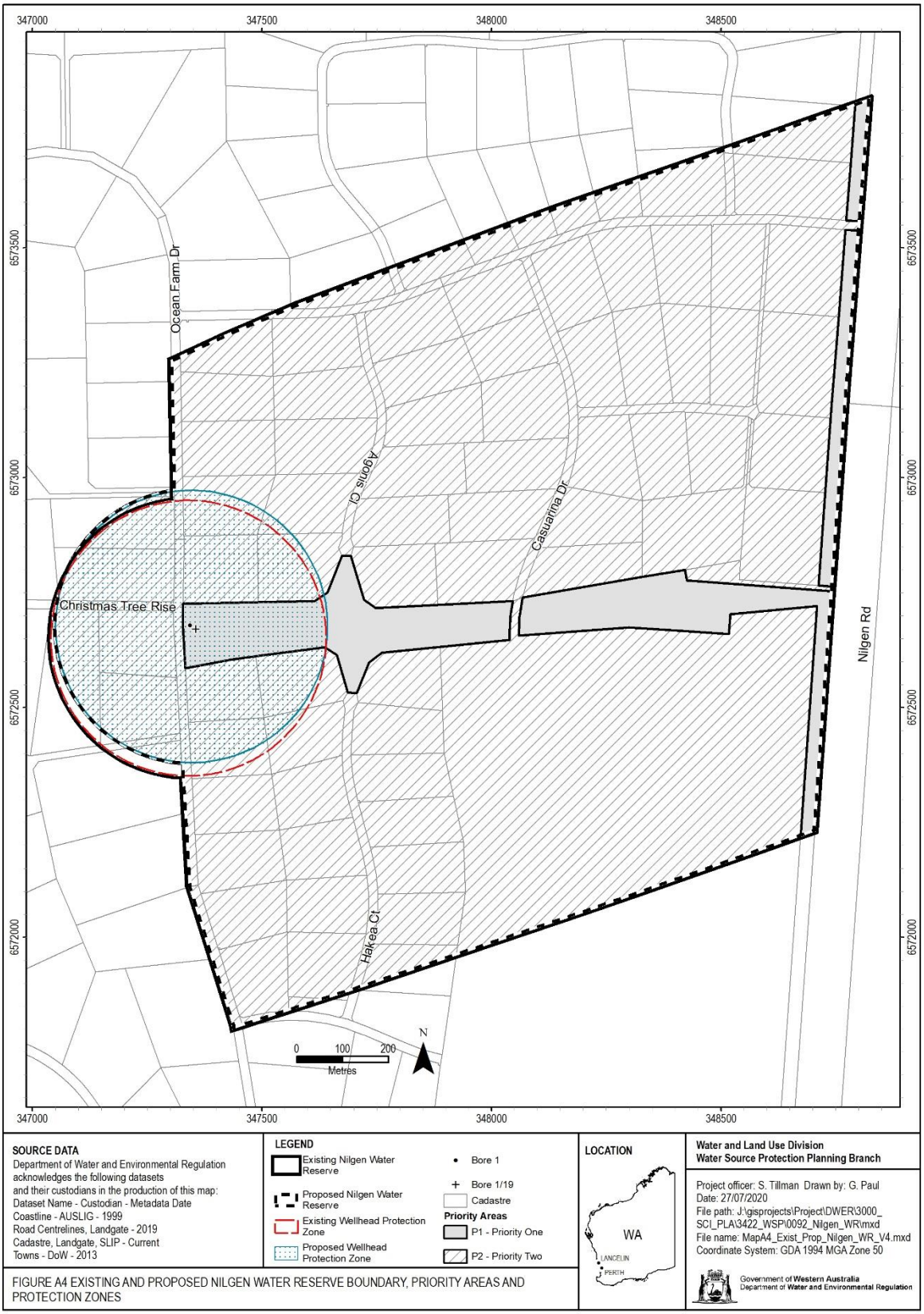

Figure A4 Existing and proposed Nilgen Water Reserve boundary, priority areas and protection zones

Figure A5 South West Native Title Agreement area (source: Department of Premier and Cabinet)

Appendix B – Water quality data

The information provided in this appendix has been supplied by the Water Corporation.

The Water Corporation has monitored the raw (source) water quality from Nilgen in accordance with the requirements of the *Australian drinking water guidelines* (ADWG; NHMRC & NRMMC 2011, August 2018 update) and interpretations agreed to with the Department of Health. This data shows the quality of raw water in the public drinking water source area (PDWSA). The raw water is monitored regularly for:

- aesthetic characteristics (non-health-related)
- health-related characteristics (chemical, radiological and microbiological hazards).

The following data represents the quality of raw water from Nilgen Water Reserve. In the absence of specific guidelines for raw-water quality, the results have been compared with the ADWG values set for drinking water, which defines the quality requirements at the consumer's tap. Any water quality parameters that have been detected are reported; those that on occasion have exceeded the ADWG guideline values are in bold and italics to give an indication of potential raw-water quality issues associated with this source. The values are taken from ongoing monitoring for the period December 2014 to December 2019.

It is important to appreciate that the raw-water data presented does not represent the quality of drinking water distributed to the public. Barriers such as storage and water treatment exist downstream of the raw water to ensure that drinking water supplied to consumers meets the requirements of the ADWG.

For more information on the quality of drinking water supplied to the Nilgen area refer to the most recent Water Corporation drinking water quality annual report at www.watercorporation.com.au.

Aesthetic characteristics

The aesthetic quality analyses for raw water from Nilgen Water Reserve are summarised in the following table.

Table B1 Aesthetic detections for Nilgen Water Reserve

Parameter	Units	ADWG aesthetic guideline value[1]	Nilgen bore field raw water		
			Number of samples	Range	Mean
Chloride	mg/L	250	22	130–150	138
Hardness as $CaCO_3$	mg/L	200	22	***230–260***	***248***
Iron unfiltered	mg/L	0.3	22	<0.003–0.22	0.04
Silicon as SiO_2	mg/L	80	22	18–22	20
Sodium	mg/L	180	22	80–94	88
Sulfate	mg/L	250	22	17–19	18
Total filterable solids by summation	mg/L	600	22	***627–690***	***663***
Turbidity	NTU	5	22	<0.1–4.2	0.5
pH measured in laboratory	No units	6.5–8.5	22	7.15–7.76	7.42

[1] An aesthetic guideline value is the concentration or measure of a water quality characteristic that is associated with good quality water.

Health-related characteristics

Raw water from Nilgen is analysed for chemicals that are potentially harmful to human health, including inorganics, heavy metals, industrial hydrocarbons, radiological characteristics and pesticides. Health-related characteristics that have been detected in the source are summarised in the following table.

Table B2 Health-related detections for Nilgen Water Reserve

Parameter	Units	ADWG health guideline value[1]	Nilgen bore field raw water		
			Number of samples	Range	Mean
Manganese unfiltered	mg/L	0.5	22	<0.002–0.005	0.004
Nitrate	mg/L	50[2]	22	20.2–26.4	24.2
Arsenic	mg/L	0.01	14	0–0.003	0.002

[1] A health guideline value is the concentration or measure of a water quality characteristic that, based on present knowledge, does not result in any significant risk to the health of the consumer over a lifetime of consumption (NHMRC & NRMMC 2011, August 2018 update).

[2] A guideline value of 50 mg/L (as nitrate) has been set to protect bottle-fed infants under three months of age. Up to 100 mg/L (as nitrate) can be safely consumed by adults and children over three months of age (NHMRC & NRMMC 2011, August 2018 update).

Microbiological contaminants

Microbiological testing of raw-water samples from Nilgen raw water point is currently conducted on a monthly basis.

Escherichia coli counts are used as an indicator of the degree of recent faecal contamination of the raw water from warm-blooded animals. A detection of *E. coli* in raw water may indicate contamination of faecal material.

During the reviewed period, 66 samples were taken for *E. coli*. Positive *E. coli* counts were recorded in 2 samples (3 per cent).

During the review period, 40 samples were taken for *thermophilic Naegleria.* There were no detections of *Naegleria*.

Cyanobacteria is not monitored at this groundwater source.

Appendix C – Photographs

Photographs by S.Tillman, Department of Water and Environmental Regulation

Photograph C1 Nilgen bore field and treatment compound (looking east)

Photograph C2 Bore 1/19 (blue) has been drilled in the same compound as Bore 1 but is not yet equipped to abstract water (looking west)

Photograph C3 Ocean Farms Drive runs past the Nilgen bore field and treatment plant. Electrical supply for the site (looking south)

Photograph C4 Nilgen tank site (5 tanks) stores treated drinking water before being gravity fed to residences

Photograph C5 Signage in the Nilgen Water Reserve (looking east)

Photograph C6 Access track on crown land between bore field and tank site with rural living land in background looking south-west (24ha lots are typical)

Appendix D – Typical contamination risks in groundwater sources

Land development and land- or water-based activities within a water reserve can directly affect the quality of drinking water and its treatment. Contaminants can reach drinking water sources through runoff over the ground and infiltration through the soil. A wide range of microbiological, chemical and physical contamination risks can impact on water quality and therefore affect the provision of reliable, safe, good quality drinking water to consumers.

Some contaminants in drinking water can affect human health, resulting in illness, hospitalisation or even death. Other impurities can affect the water's aesthetic qualities, including its appearance, taste, smell and 'feel' but are not necessarily hazardous to human health. For example, cloudy water with a distinctive odour or strong taste may not be harmful to health, but clear, pleasant-tasting water may contain harmful microorganisms that are undetectable by sight, taste or smell (NHMRC & NRMMC 2011). Contaminants can also interfere with water treatment processes and damage infrastructure.

The *Australian drinking water guidelines* (ADWG; NHMRC & NRMMC 2011, August 2018 update) outline criteria for acceptable drinking water quality to protect human health, manage aesthetics and maintain water supply infrastructure.

Some commonly seen contamination risks relevant to groundwater drinking water sources are described below.

Microbiological risks

Pathogens are types of microorganisms that are capable of causing illness and include bacteria, protozoa and viruses. When people consume drinking water that is contaminated with pathogens, the consequences vary considerably, ranging from mild illness (such as stomach upset or diarrhoea) to hospitalisation and in some cases even death. For example, seven people died and about 2500 became ill in Walkerton, Canada, during 2000, because the town's water supply was contaminated by a pathogenic strain of *Escherichia coli* and *Campylobacter* (NHMRC & NRMMC 2011).

The types of pathogens that are likely to cause harm to people are commonly found in the faeces of humans and domestic animals (such as dogs and cattle). These pathogens can enter drinking water supplies from faecal contamination in the catchment area, either directly or indirectly.

In groundwater sources, this occurs indirectly. Faecal material can infiltrate through the soil and into the groundwater. For example, contamination can occur from septic tanks or grazing animals.

A number of pathogens are commonly known to contaminate water supplies worldwide. These include bacteria (for example *Salmonella*, *Escherichia coli* and cholera), protozoa (such as *Cryptosporidium* and *Giardia*) and viruses. Monitoring for

the presence of *E. coli* in water supplies provides an indication of the level of recent faecal contamination.

Pathogen contamination of a drinking water source is influenced by many factors including the existence of pathogen carriers (humans and domestic animals), the transfer to and movement of the pathogen in the water source and its ability to survive in the water.

The percentage of humans in the world that carry pathogens varies. For example, it is estimated that between 0.6 to 4.3 per cent of people are infected with *Cryptosporidium* worldwide, and 7.4 per cent with *Giardia* (Geldreich 1996).

The survival and movement of pathogens in groundwater is influenced by the characteristics of the pathogen (such as its size and inactivation rate) and the groundwater properties (including flow rate, porosity, amount of carbon in the soil, temperature and pH). Inactivation rate (the time it normally takes a pathogen to decay) is one of the most important factors governing how far pathogens may migrate. Typical half-lives of pathogens range from a few hours to a few weeks. For example, some reported migration distances of bacteria in groundwater are:

- 600 m in a sandy aquifer
- 1000–1600 m in channelled limestone
- 250–408 m in glacial silt-sand aquifers (Robertson & Edbery 1997).

Unlike chemicals, which dissipate and dilute when they enter a water source, pathogens can multiply under the right conditions, increasing the likelihood of contamination. Therefore it is important to understand both the surface water and groundwater systems to be able to protect the drinking water source from pathogens.

Given the wide variety of pathogens, their behaviour in the environment and the potential consequences of consuming contaminated water, the most effective way to protect public health and reduce water treatment costs is to avoid the introduction of pathogens into a water source.

Physical risks

Turbidity is the result of soil or organic particles becoming suspended in water. Increased turbidity can result in cloudy or muddy-looking water, which is not aesthetically appealing to consumers. Turbidity can also reduce the effectiveness of treatment processes (such as disinfection). This is because pathogens and chemicals can attach to soil particles, making them more difficult to remove during disinfection and treatment processes.

Other physical properties of water can affect water supply infrastructure, or the aesthetics of the drinking water. For example, pH can contribute to the corrosion and encrustation of pipes; iron and dissolved organic matter can affect the colour and smell of water; and salinity levels can affect its taste. Although not necessarily harmful to human health, water with properties like this will be less appealing to customers.

Chemical risks

Chemicals can occur in drinking water as a result of natural leaching from mineral deposits or from different land uses (NHMRC & NRMMC 2011). A number of these chemicals (organic and inorganic) are potentially toxic to humans.

Pesticides include agricultural chemicals used to control weeds (herbicides) and pests (insecticides, rodenticides, nematicides (for worms) and miticides (for mites)). Contamination of a drinking water source by pesticides (and other chemicals) may occur as a result of accidental spills, incorrect use or leakage from storage areas. In these cases, the relevant authorities should be notified promptly and the spill cleaned up to prevent contamination of the drinking water source.

Hydrocarbons such as fuels and oils are potentially toxic to humans. Harmful chemical by-products may be formed when hydrocarbons are combined with chlorine during the water treatment process. Hydrocarbons can occur in water supplies as a result of spills and leaks from vehicles and machinery.

Drinking water sources can also be contaminated by nutrients such as nitrogen and phosphorus. Nutrients can be introduced into a catchment via the application of fertiliser and from septic systems and animal faecal matter that washes through soil and into the groundwater. Nitrate and nitrite are two forms of nitrogen that can be toxic to humans at high levels, with infants younger than three months being most susceptible (NHMRC & NRMMC 2011).

Other chemicals and heavy metals can be associated with land uses such as industry and landfill. These may enter groundwater and could be harmful to human health if consumed.

Appendix E – Assessing and managing risks in public drinking water source areas

Introduction

Drinking water for Western Australia's cities and towns comes from a variety of sources including the traditional dams (surface water catchments) and bores (groundwater), and more contemporary alternatives like desalination and recycled water. Even with climate change leading to a reduced reliance on the traditional water sources, they are still highly valuable. Fortunately, we can use alternative sources to ensure we continue to meet the state's water needs.

Protecting these drinking water sources allows us to maximise water quality benefits for the health and development needs of the state. Additionally, this protection significantly reduces the costs of running our public water supply schemes. The affordable traditional sources act to offset the more expensive alternative sources.

The protection of traditional and alternative public drinking water sources is important to ensure the ongoing availability of safe, reliable, good quality, affordable drinking water for current and future generations.

WA's drinking water protection program is world's best practice and will ensure we can meet the needs of our growing population. It uses a precautionary approach based on preventing risks (i.e. a preventive risk-based approach) that is proven to maximise the protection of water quality and public health. This means that some land uses need to be restricted within public drinking water source areas. Fortunately, we have large areas of land available for development when compared to the small areas of land that are protected for public drinking water supply. Sometimes however, especially around existing towns and cities, the competing interests of land development and drinking water source protection means we have to consider a compromise. WA's drinking water protection program recognises this and ensures that state and local government work together to achieve the best possible.

This information sheet explains what the preventive risk-based approach is, how the Department of Water and Environmental Regulation implements it, and the outcomes it achieves.

Public drinking water source areas

Drinking water for cities and towns across WA comes from a combination of surface water catchments, groundwater aquifers, seawater desalination plants, and water recycling. Our surface water catchments and groundwater aquifers are collectively called 'public drinking water source areas' (PDWSAs). Most of these drinking water sources are legally constituted to recognise and protect their drinking water value. Constitution enables by-laws to be applied that help us protect water quality and public health in these PDWSAs. It also ensures all stakeholders can locate PDWSAs on spatial databases.

Land development and land- or water-based activities within a PDWSA can directly affect the quality of drinking water and the level of treatment it needs to make it safe to drink. Contaminants can enter drinking water sources through runoff over the ground and infiltration through the soil. A wide range of microbiological, chemical and physical contaminants can affect water quality and public health.

Australian drinking water guidelines

The *Australian drinking water guidelines* (ADWG; NHMRC & NRMMC 2011, August 2018 update) outline how best to manage drinking water supplies in Australia. The guidelines recommend a 'catchment to consumer' framework that uses a preventive (or precautionary) risk-based approach in conjunction with addressing contamination risks through multiple barriers. The National Health and Medical Research Council (NHMRC) and the Natural Resource Management Ministerial Council of Australia (NRMMC) regularly update the ADWG to ensure it consistently meets the highest global standards.

In May 2019, the Minister for Health endorsed that the ADWG be followed in WA. The Department of Water and Environmental Regulation, the Department of Health, the Water Corporation and other water service providers all support and implement the ADWG.

The World Health Organization (WHO) also encourages a preventive risk-based approach with a focus on protecting PDWSAs in combination with treatment. Australian Standards also recommend that similar preventive risk approaches are used.

'Catchment to consumer' and multiple barriers (element three of the ADWG)

The ADWG's 'catchment to consumer' framework consists of 12 elements that apply to the entire drinking water supply system – from the catchment of the water source to the taps in our homes (see Figure 1). The framework assesses and manages risks at every stage of the system, ensuring a holistic approach to delivering safe and reliable drinking water.

The department looks at the 'catchment' part of the framework (elements two and three of the ADWG), in consultation with the Department of Health and licensed water service providers. Once the water leaves the catchment (or the 'PDWSA'), the Department of Health and the licensed water service provider assess and manage the risks for the rest of the supply system.

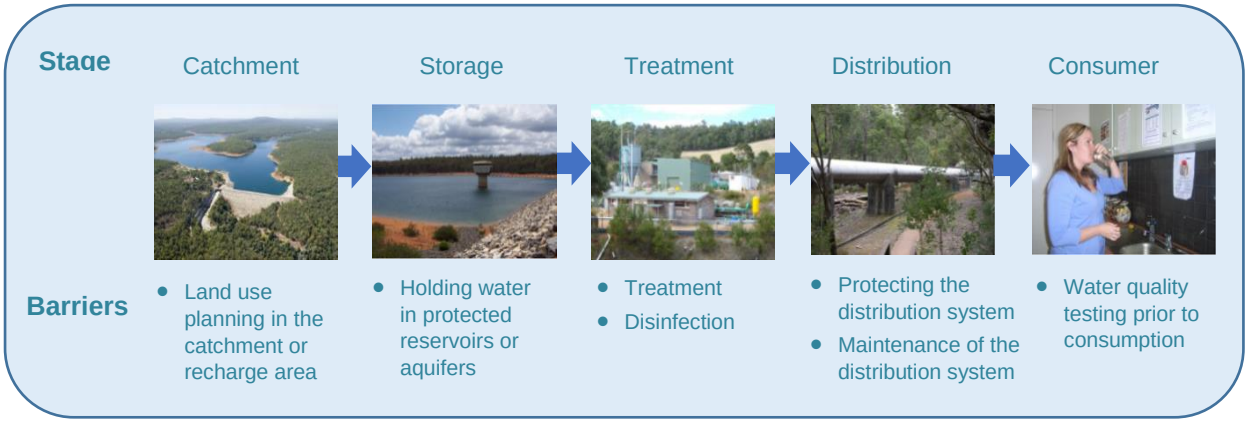

Figure E1: The 'catchment to consumer' framework

Different barriers against contamination are used at different stages of the 'catchment to consumer' system to ensure the maximum protection for consumers. The first and most important barrier is protecting the source of drinking water (the PDWSA). This is the first barrier and its protection has a flow-on effect, reducing the complexity of barriers required at other stages. Other barriers against contamination include the storage of water to help reduce contaminant levels; treatment plant disinfection of the water (such as chlorination to reduce the number of pathogens) and other treatment; maintenance and treatment within distribution piping and water quality testing at the tap.

Prevention is an essential feature of modern drinking water quality management. Research and experience shows that a combination of catchment protection (e.g. sound land use planning) and water treatment is safer than relying on either barrier on its own. The more land uses and activities that occur in an area the higher the risk of contamination. Therefore as land uses are intensified, more mitigation is needed to address contamination risks. In PDWSAs the aim is to maintain or improve water quality through measures such a restrictions on land use intensification. Figure 2 shows the risk profiles of land use intensification and development against the level of protection applied.

Shortened forms

List of shortened forms

ABS	Australian Bureau of Statistics
ADWG	*Australian drinking water guidelines*
GIS	geographic information system
HAZMAT	hazardous materials
ILUA	Indigenous land use agreement
LEMC	local emergency management committee
NHMRC	National Health and Medical Research Council
NRMMC	Natural Resource Management Ministerial Council
P1, P2, P3	priority 1, priority 2, priority 3
PSC 88	Public sector circular number 88
PDWSA	public drinking water source area
Westplan–HAZMAT	See *State Hazard Plan – HAZMAT* in Glossary
WHPZ	wellhead protection zone
WQPN	water quality protection note

Units of measurement

ha	hectares	A measure of area, 1 ha equals 10,000 m^2.
km	kilometres	A measure of distance, 1 km equals 1000 m.
m	metres	A measure of distance.
m^2	square metres	A measure of area.
mg/L	milligrams per litre	A measure of concentration of a substance in a solution.
NTU	nephelometric turbidity units	A measure of turbidity in water.

pH	A logarithmic scale for expressing the acidity or alkalinity of a solution; a pH below 7 indicates an acidic solution and above 7 indicates an alkaline solution.

Volumes of water

One millilitre	0.001 litre	1 millilitre	(mL)
One litre	1 litre	1 litre	(L)
One thousand litres	1,000 litres	1 kilolitre	(kL)
One million litres	1,000,000 litres	1 megalitre	(ML)
One thousand million litres	1,000,000,000 litres	1 gigalitre	(GL)

Glossary

Abstraction	The pumping of groundwater from an aquifer, or the removal of water from a waterway or water body.
Aesthetic guideline value	The concentration or measure of a water quality characteristic that is associated with acceptability of water to the consumer, for example appearance, taste and odour (NHMRC & NRMMC 2011).
Allocation	The volume of water that a licensee is permitted to abstract, usually specified in kilolitres per year (kL/y).
Allocation limit	A calculated limit placed on a ground or surface water resource indicating the maximum amount that can be taken from it before impacting on other users and the environment.
Aquifer	A geological formation or group of formations able to receive, store and transmit significant quantities of water.
Australian drinking water guidelines	The *National water quality management strategy: Australian drinking water guidelines 6* (ADWG; NHMRC & NRMMC 2011, August 2018 update) outlines acceptable criteria for the quality of drinking water in Australia (see *References*).
Bore	A narrow, lined hole drilled into the ground to monitor or draw groundwater (also called a well).
Bore field	A group of bores to monitor or withdraw groundwater (also see *wellfield*).
Catchment	The area of land which intercepts rainfall and contributes the collected water to surface water (streams, rivers, wetlands) or groundwater.
Constitute	Define the boundaries of any catchment area or water reserve by Order in Council under the *Country Areas Water Supply Act 1947* or by proclamation under *the Metropolitan Water Supply, Sewerage and Drainage Act 1909*.
Contamination	A substance present at concentrations exceeding background levels that presents – or has the potential to present – a risk of harm to human health, the environment, water resources or any environmental value.
Dissipate	To become scattered or dispersed.

Drinking water source protection report	A report on water quality risks within a public drinking water source area, including recommendations to avoid, minimise, or manage those risks for provision of safe drinking water supply.
Effluent	Treated or untreated liquid, solid or gaseous waste discharged by a process such as through a septic tank and leach drain system.
Gazette	Publication within the Government Gazette of Western Australia of the Order in Council or proclamation defining the boundaries of any catchment area or water reserve.
Health guideline value	The concentration or measure of a water quality characteristic that, based on current knowledge, does not result in any significant risk to the health of the consumer over a lifetime of consumption (NHMRC & NRMMC 2011).
Hydrocarbons	A class of compounds containing only hydrogen and carbon, such as methane, ethylene, acetylene and benzene. Fossil fuels such as oil, petroleum and natural gas all contain hydrocarbons.
Hydrogeology	The branch of geology that deals with the occurrence, distribution and effects of groundwater. It is the study of groundwater, especially relating to the distribution of aquifers, groundwater flow and groundwater quality.
Leaching/ leachate	The process by which materials such as organic matter and mineral salts are washed out of a layer of soil or dumped material by being dissolved or suspended in percolating rainwater. The material washed out is known as leachate. Leachate can pollute groundwater and waterways.
Maximum risk	This is the level of risk in the absence of any preventive measures (barriers) being installed in the system, or assuming that preventive measures have failed. Assessing maximum risk is useful for identifying high priority risks, determining where attention should be focused and preparing for emergencies (NHRMC & NRMMC 2011).
Microbe	A microorganism, usually one of vegetable nature, a germ. Also known as a bacterium, especially one causing illness.
Nutrient load	The amount of nutrient reaching the waterway over a given timeframe (usually per year) from its catchment area.
Nutrients	Minerals, particularly inorganic compounds of nitrogen (nitrate and ammonia) and phosphorous (phosphate) dissolved in water which provide nutrition (food) for plant growth.

Order in Council	Made under the Governor of Executive Council and published in the Government Gazette to constitute or abolish a catchment area or water reserve under section 9 of the *Country Areas Water Supply Act 1947.*
Pathogen	A disease-producing organism that can cause sickness and sometimes death through the consumption of water, including bacteria (such as *Escherichia coli*), protozoa (such as *Cryptosporidium* and *Giardia*) and viruses.
Permeability	Also referred to as hydraulic conductivity, this is the ability of a rock or soil unit to transmit fluids. Its magnitude depends on the size of the pore spaces (see porosity) and the degree to which they are interconnected.
Pesticides	Collective name for a variety of insecticides, fungicides, herbicides, algicides, fumigants and rodenticides used to kill organisms.
Pollution	Water pollution occurs when waste products change the physical, chemical or biological properties of the water, adversely affecting water quality, the ecosystem and beneficial uses of the water.
Porosity	The ratio of water (or air) filled pore spaces to the total volume of the rock or soil, expressed as a percentage or fraction.
Proclamation	Made under the Governor of Executive Council and published in the Government Gazette to constitute or abolish a water reserve, catchment area or underground water pollution control area under section 13 and 57A of the *Metropolitan Water Supply, Sewerage, and Drainage Act 1909.*
Public drinking water source area	The area from which water is captured to supply drinking water. It includes all underground water pollution control areas, catchment areas and water reserves constituted under the *Metropolitan Water Supply, Sewerage, and Drainage Act 1909* or the *Country Areas Water Supply Act 1947*.
Priority 1, 2 and 3	Three different priority areas are assigned within PDWSAs to guide land use decisions. The objective of priority 1 (P1) areas is *risk avoidance*, priority 2 (P2) areas is *risk minimisation* and priority 3 (P3) areas is *risk management*.
Public sector circular number 88	A state government circular produced by the Department of Health providing guidance on appropriate herbicide use within water catchment areas.

Recharge	The action of water infiltrating through the soil/ground to replenish an aquifer.
Recharge area	An area through which water from a groundwater catchment percolates to replenish (recharge) an aquifer. An unconfined aquifer is recharged by rainfall throughout its distribution. Confined aquifers are recharged in specific areas where water leaks from overlying aquifers, or where the aquifer rises to meet the surface.
Residual risk	This is the level of risk after considering preventive measures (barriers) that are applied in the drinking water supply system, such as fencing to keep cattle away from drinking water bores, or surveillance to identify people accessing protected areas. Residual risk provides an indication of how effective preventive strategies are, or the need for additional preventive measures (NHRMC & NRMMC 2011).
Runoff	Water that flows over the surface from a catchment area, including streams.
Scheme supply	Water diverted from a source or sources by a water authority or private company and supplied via a distribution network to customers for urban and industrial use or for irrigation.
Sole supply	The only source of drinking water for a given town or community. These sources are important to protect as there are no other current options to supply drinking water for that location.
State Hazard Plan – HAZMAT	Each defined and prescribed hazard in the state, for example HAZMAT, has a dedicated State Hazard Plan (previously Westplan) that outlines the arrangements on how to manage that hazard across the prevention, preparation, response and recovery spectrum. State Hazard Plans are managed by the State Emergency Management Committee (www.semc.wa.gov.au). Previously called Western Australian hazardous materials emergency management scheme (WAHMEMS).
Superficial aquifer	Shallow (near to the surface) aquifers which are easily recharged and can be readily accessed by bores.
Treatment	Application of techniques such as settlement, filtration and chlorination to render water suitable for specific purposes, including drinking and discharge to the environment.
Turbidity	The cloudiness or haziness of water caused by the presence of fine suspended matter.

Unconfined aquifer	An aquifer where the upper boundary is the watertable and therefore is in contact with the atmosphere through the pore spaces in the unsaturated zone. Typically (but not always) it is the shallowest aquifer at a given location.
Wastewater	Water that has been used for some purpose and would normally be treated and discarded. Wastewater usually contains significant quantities of pollutant.
Water quality	Collective term for the physical, aesthetic, chemical and biological properties of water.
Water reserve	An area constituted under the *Country Areas Water Supply Act 1947* or the *Metropolitan Water Supply, Sewerage, and Drainage Act 1909* for the purposes of protecting a drinking water supply.
Watertable	The upper saturated level of the unconfined groundwater.
Wellhead	The top of a well (or bore) used to draw groundwater.
Wellhead protection zone	Usually declared around wellheads in public drinking water source areas to protect the groundwater from immediate contamination risks.

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Department of Water and Environmental Regulation
Prime House
8 Davidson Terrace Joondalup
Western Australia 6027

Locked Bag 10, Joondalup DC WA 6919

Phone: 08 6364 7000
Fax: 08 6364 7001
National Relay Service 13 36 77
dwer.wa.gov.au